# Full-pulse tomographic reconstruction with deep neural networks

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Plasma tomography consists in reconstructing the 2D plasma profile on a cross-section of the fusion device, based on radiation measurements taken along several lines of sight. In JET, there is a horizontal camera (KB5H) and a vertical camera (KB5V) with 24 bolometers each, and with a sampling rate of 5 kHz. This means that a 30-second pulse could, in principle, yield as much as 150,000 reconstructions. However, the reconstruction process is usually attained through iterative regularization methods, which are computationally intensive. On average, only a few reconstructions are actually computed per pulse.

In previous work [1], we have shown that a deep neural network with several up-convolutional layers (up-sampling + convolution) can approximate the results of tomographic reconstruction with high accuracy. More recently, we improved the design of such network by replacing the up-convolutional layers with deconvolutional layers (i.e. transposed convolutions) in order to obtain the logical inverse of a convolutional neural network (CNN). We have also removed the requirement for any data preprocessing, so the sensor data coming from the bolometers can be fed directly to the network.

The network has been trained on a set of 23,500 sample tomograms collected from all JET campaigns since the installation of the ITER-like wall (ILW) in 2011. We used an adaptive gradient descent algorithm with a small learning rate ($10^{-4}$) and a large batch size (400). After about 1900 epochs (8 hours on an Nvidia Titan X GPU), a minimum loss value was achieved on a holdout validation set comprising 10% of data. With the trained network, the tomographic reconstruction for an entire pulse can be performed in a matter of seconds, producing high-frame-rate videos of plasma heating, disruptions, and other phenomena.

**References**

[1] F. A. Matos, D. R. Ferreira, P. J. Carvalho, JET Contributors, "Deep learning for plasma tomography using the bolometer system at JET", Fusion Eng. Des., 114, 18-25 (2017)

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